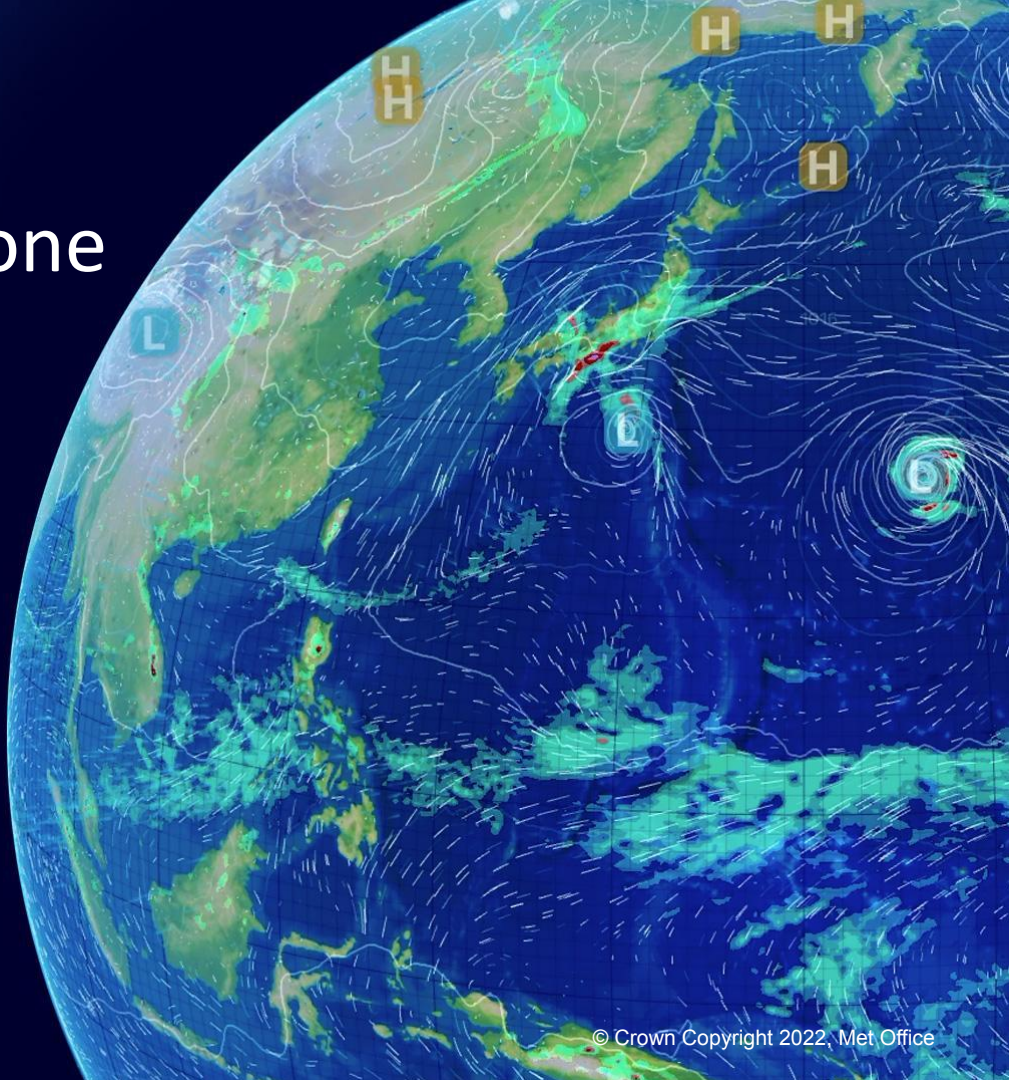


Met Office Tropical Cyclone Modelling Update

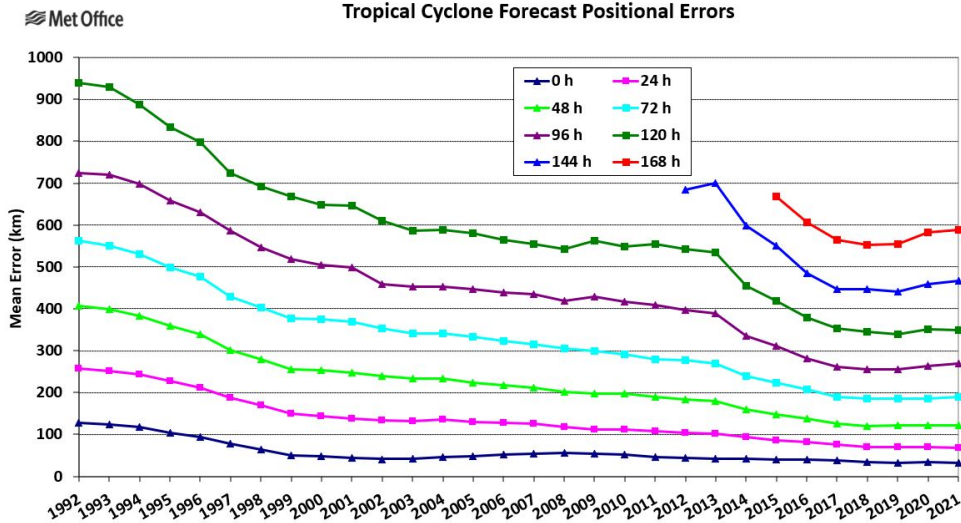
TCORF 10 March 2022

Julian Heming

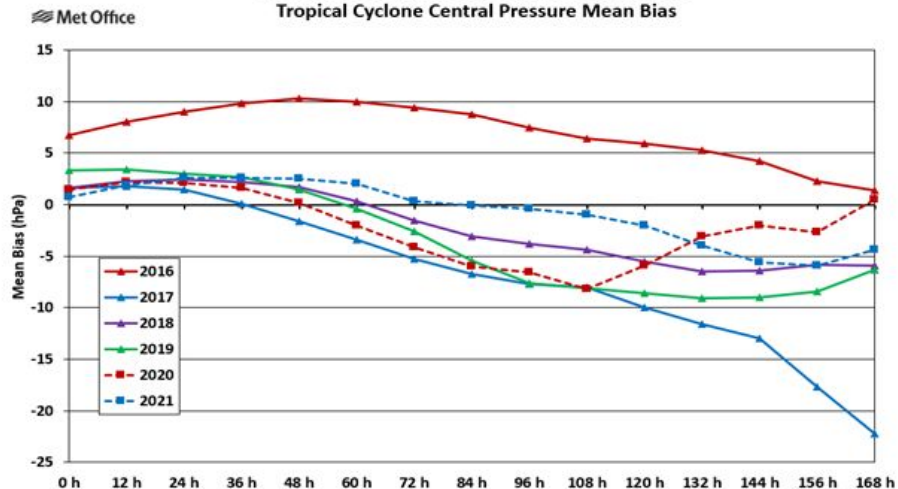


- Northern hemisphere track error on lower than 2020
- Step reduction in 2014 now dropped out of 5-year running mean
- Recent model changes no significant impact on track error
- Intensity biases and errors similar to recent seasons

Northern Hemisphere 5-year running mean
Tropical Cyclone Forecast Positional Errors



Met Office Global Model Northern Hemisphere
Tropical Cyclone Central Pressure Mean Bias

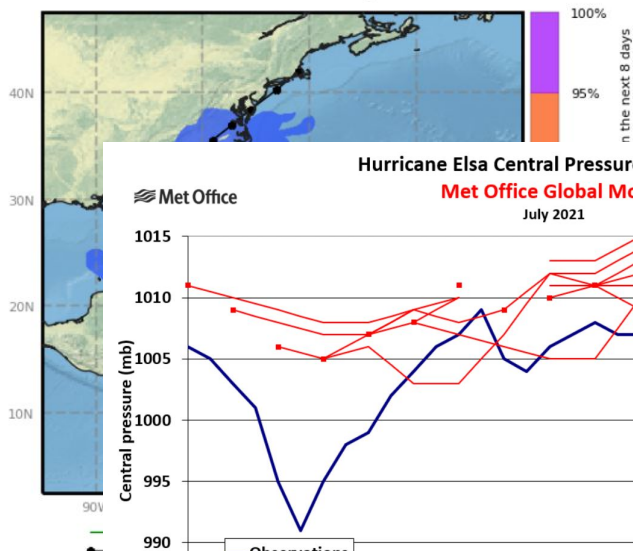


Hurricanes Elsa (left) and Grace (right)

- Met Office models good for track
- MOGREPS-G ensemble captured northwards turn a little earlier than deterministic
- Intensification phases not captured

- Several MOGREPS-G ensemble members correctly predicted path across Yucatan into Bay of Campeche out to 6+ days, with confidence increasing over subsequent runs
- Intensification in Gulf of Mexico well predicted a couple of days ahead

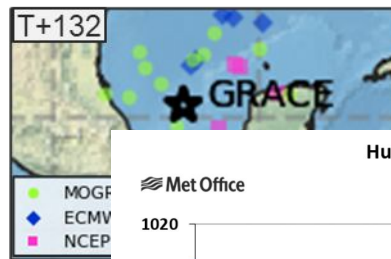
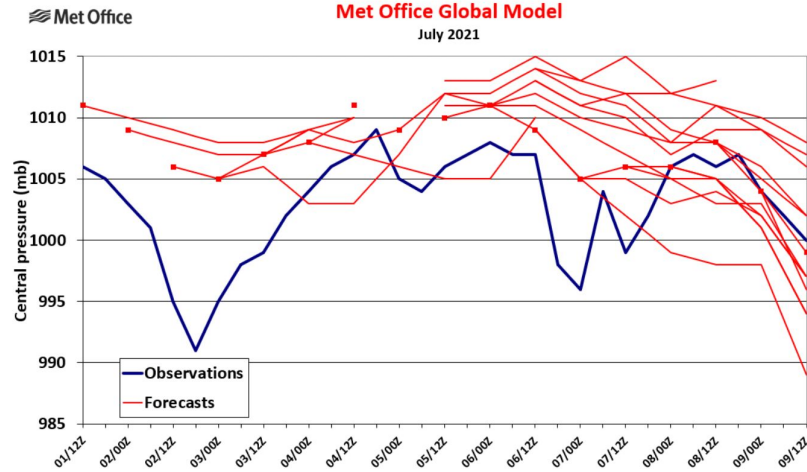
MOGREPS-G: Forecast TC track probability for ELSA from 00 UTC Fri 02 Jul 2021



Hurricane Elsa Central Pressure Predictions

Met Office Global Model

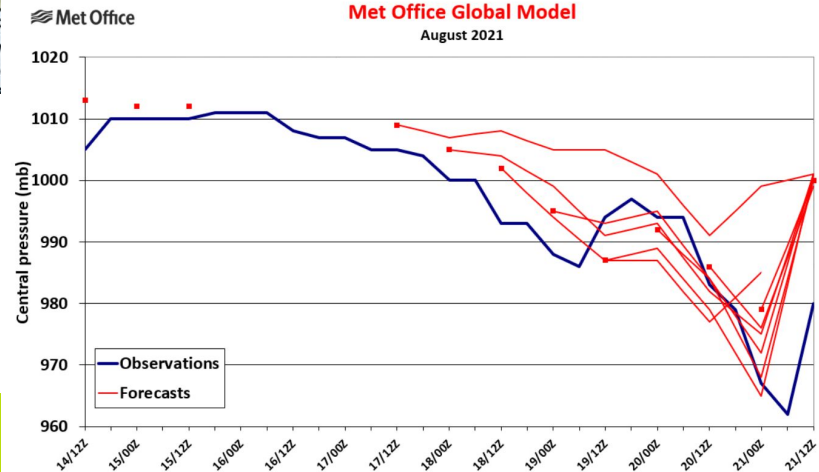
July 2021



Hurricane Grace Central Pressure Predictions

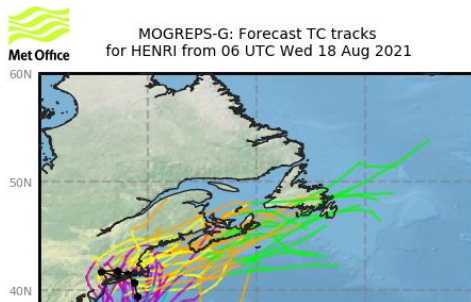
Met Office Global Model

August 2021



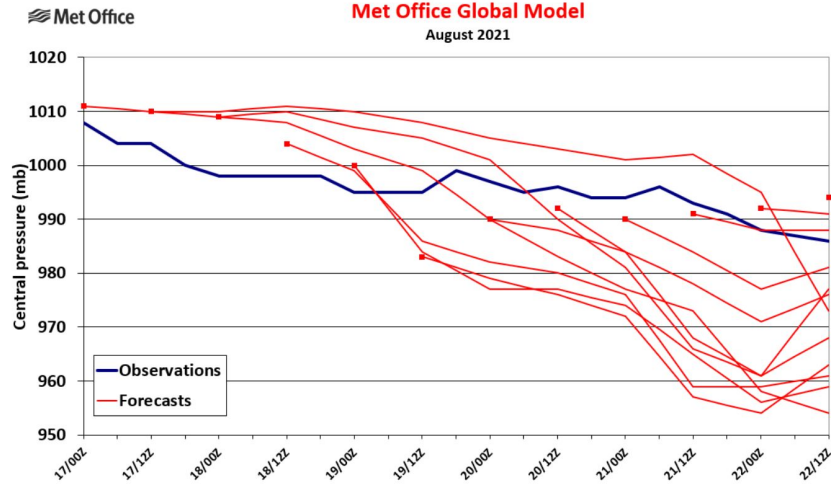
Hurricanes Henri (left) and Ida (right)

- Uncertainty in track captured by ensemble spread
- Over-intensification by deterministic model

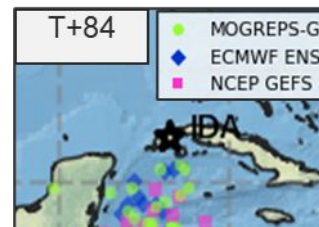


Hurricane Henri Central Pressure Predictions

Met Office Global Model
August 2021

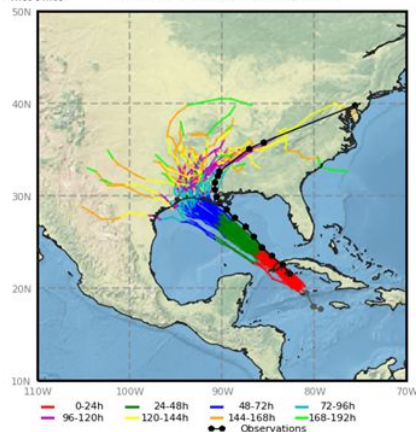


- Cyclogenesis poorly forecast in deterministic (> 48 h) and ensembles (> 72 h)
- Left bias in model forecasts, but spread covered track
- Forecast intensity too weak

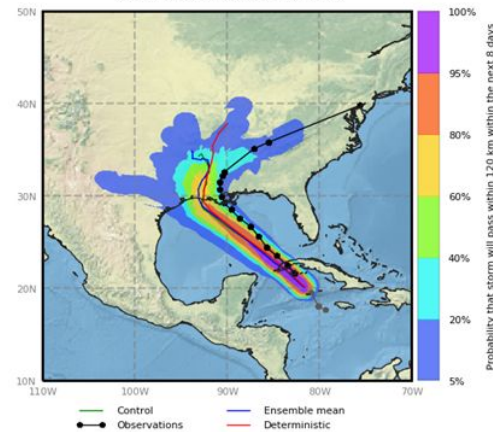


Met Office

MOGREPS-G: Forecast TC tracks
for IDA from 12 UTC Fri 27 Aug 2021



MOGREPS-G: Forecast TC track probability
for IDA from 12 UTC Fri 27 Aug 2021

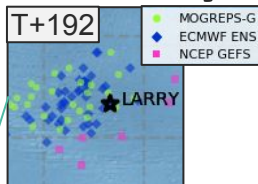
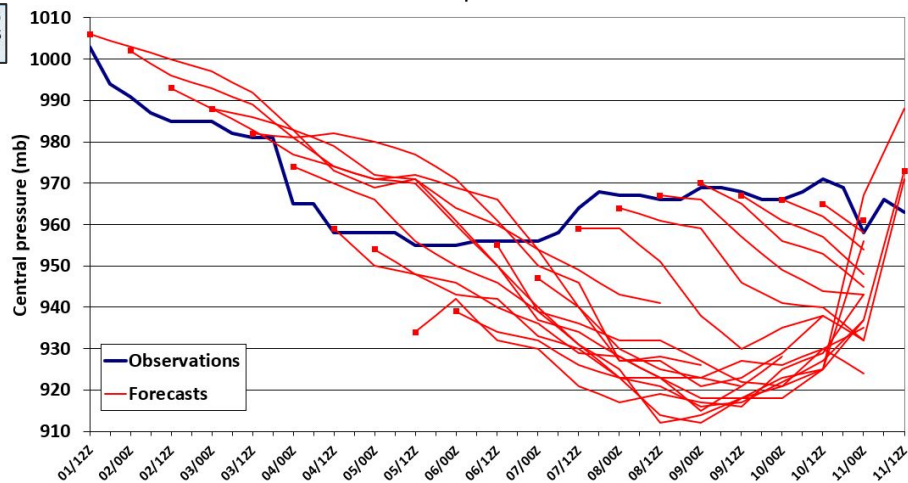


Hurricane Larry

Hurricane Larry Central Pressure Predictions

Met Office Global Model

September 2021

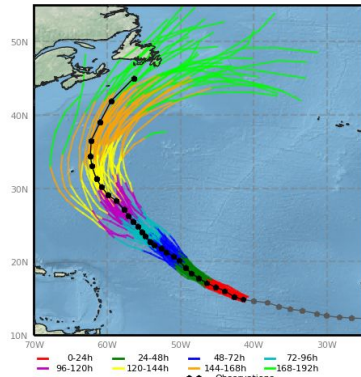


Met Office Global Model
MSLP forecasts for
Hurricane Larry
valid at
12Z 02-09-2021
4mb contour interval
blue <= 1012mb
green <= 1004mb
red <= 996mb

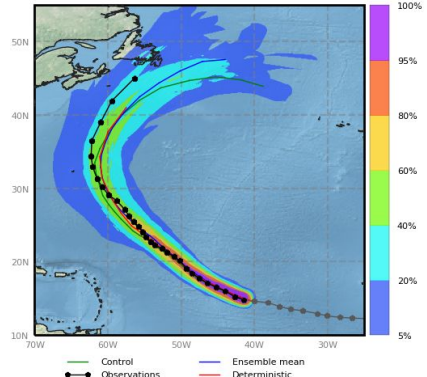
Met Office Global Model
verifying analysis



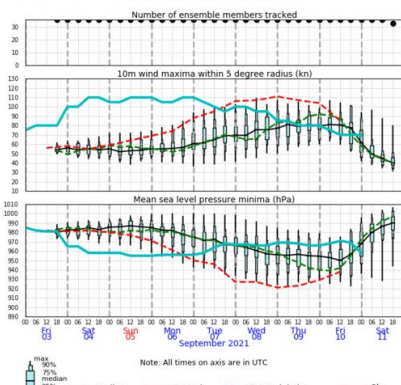
MOGREPS-G: Forecast TC tracks
for LARRY from 18 UTC Fri 03 Sep 2021



MOGREPS-G: Forecast TC track probability
for LARRY from 18 UTC Fri 03 Sep 2021



MOGREPS-G ensemble: TC-following meteorogram
LARRY (14.8N 41.5W) from 18 UTC Fri 03 September 2021

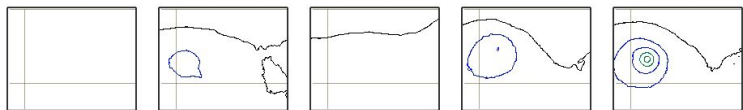


- Good for cyclogenesis
- Good for track
- Too weak in tropics, too strong in subtropics

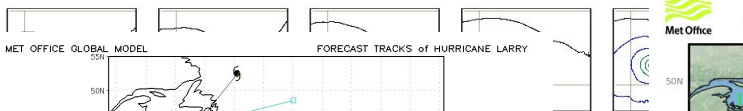
T+240 (10 days) T+228 (9.5 days) T+216 (9 days) T+204 (8.5 days) T+192 (8 days)



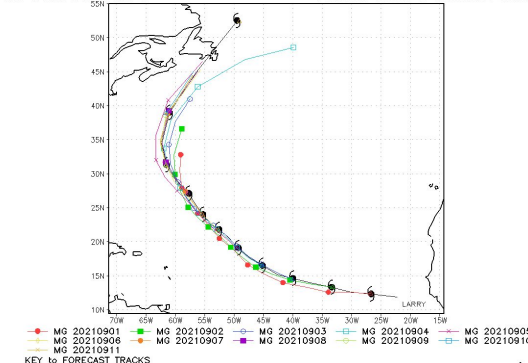
T+180 (7.5 days) T+168 (7 days) T+156 (6.5 days) T+144 (6 days) T+132 (5.5 days)



T+120 (5 days) T+108 (4.5 days) T+96 (4 days) T+84 (3.5 days) T+72 (3 days)



MET OFFICE GLOBAL MODEL FORECAST TRACKS of HURRICANE LARRY



Hurricane Sam

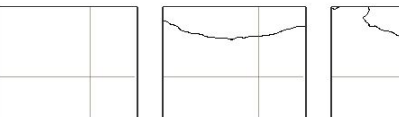
- Small TC – weak cyclogenesis
- Left-of-track bias in models, but captured by ensemble spread
- Weak bias even into higher latitudes

T+240 (10 days) T+228 (9.5 days) T+216 (9 days) T+204 (8.5 days) T+192 (8 days)

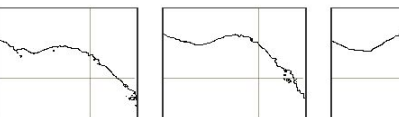


Met Office Global Model
MSLP forecasts for
Hurricane Sam
valid at
12Z 24-09-2021
4mb contour interval
blue <= 1012mb
green <= 1004mb
red <= 996mb

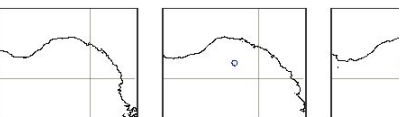
T+180 (7.5 days) T+168 (7 days) T+156 (6 days)



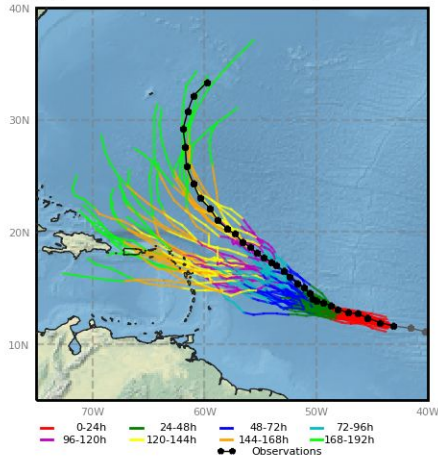
T+120 (5 days) T+108 (4.5 days) T+96 (4 days)



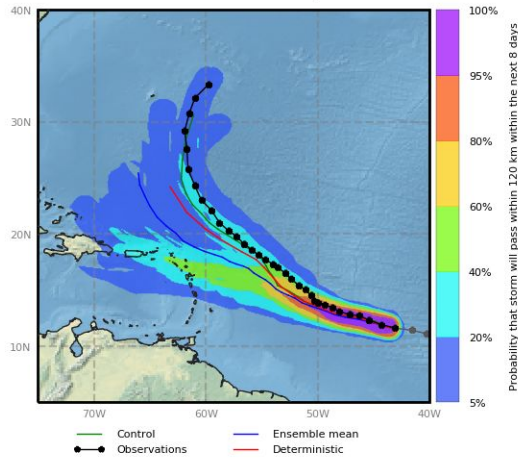
T+60 (2.5 days) T+48 (2 days) T+36 (1.5 days)



MOGREPS-G: Forecast TC tracks
for SAM from 12 UTC Fri 24 Sep 2021



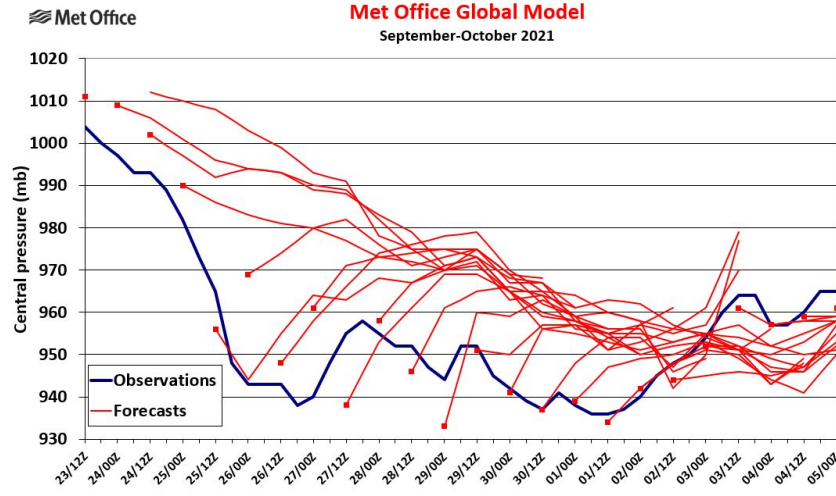
MOGREPS-G: Forecast TC track probability
for SAM from 12 UTC Fri 24 Sep 2021



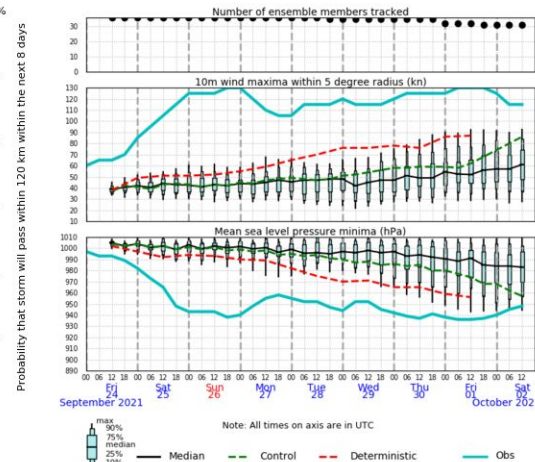
Hurricane Sam Central Pressure Predictions

Met Office Global Model

September-October 2021



MOGREPS-G ensemble: TC-following meteogram
SAM (11.6N 43.1W) from 12 UTC Fri 24 September 2021

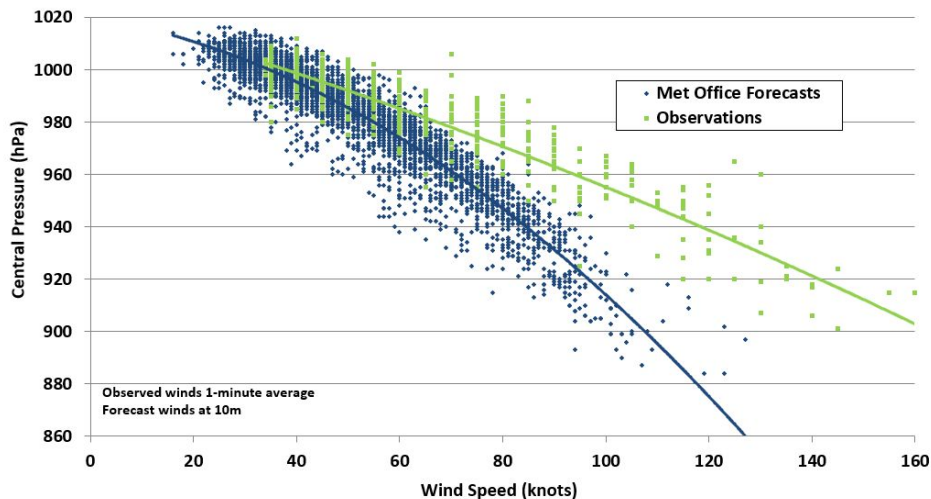


- Capped drag at high wind speeds implemented in global model late 2020
- Increases wind with no change in pressure for high wind speeds
- Clear improvement in wind-pressure relationship in 2021

**Met Office Global Model Tropical Cyclone
Wind-Pressure Scatter Plot 2020**

All tropical cyclones in 2020 and all forecast lead times 0 h to 168 h

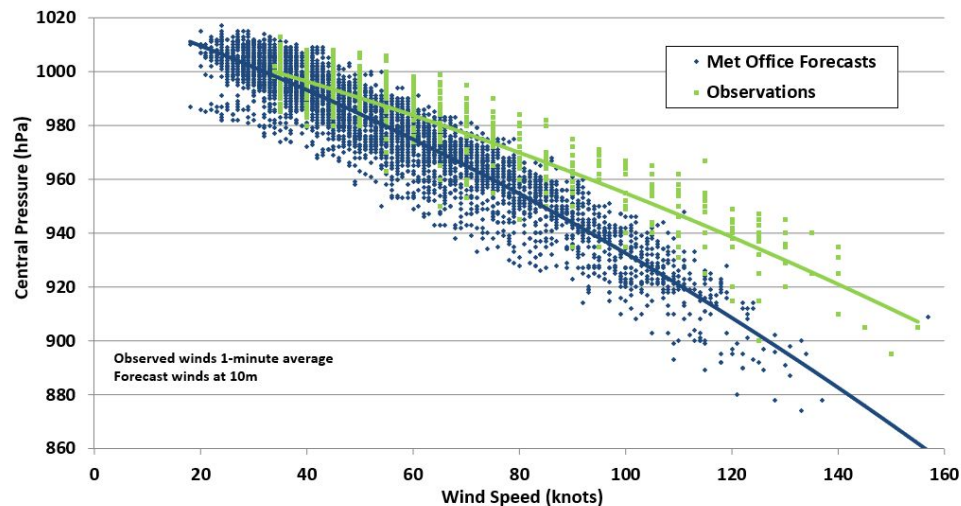
 Met Office



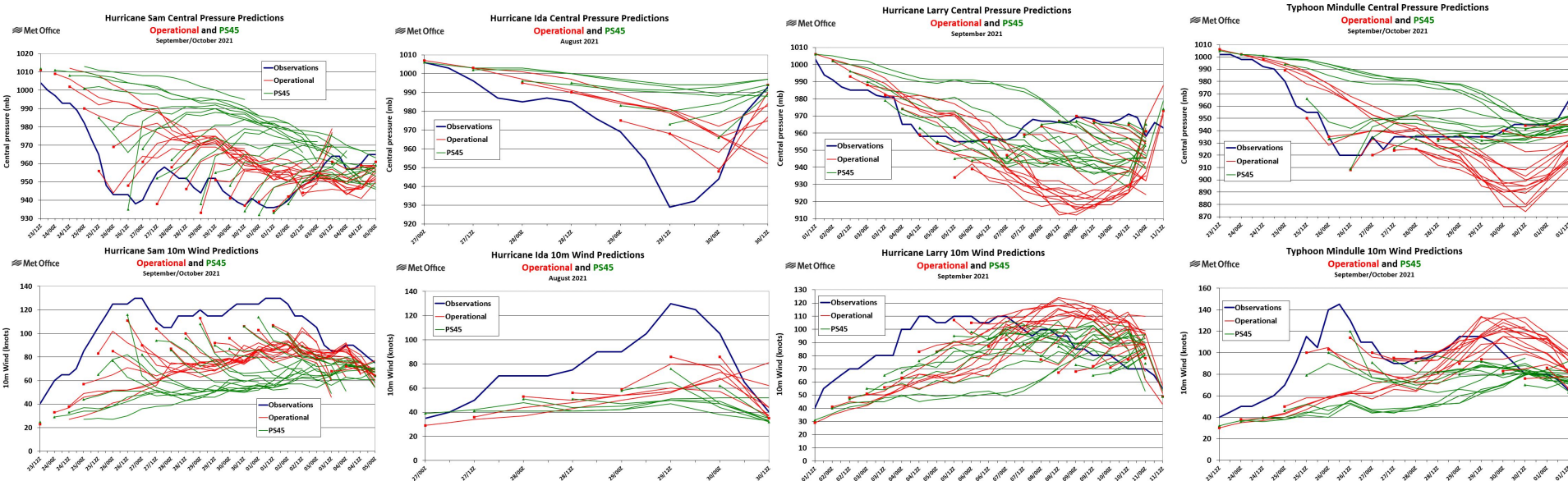
**Met Office Global Model Tropical Cyclone
Wind-Pressure Scatter Plot 2021**

All tropical cyclones in 2021 and all forecast lead times 0 h to 168 h

 Met Office



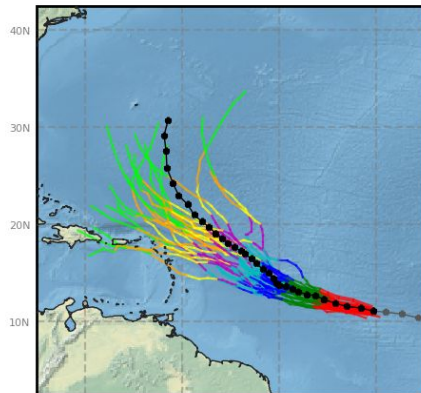
- Package of changes including ocean coupling and prognostic entrainment (convective memory)
- TCs systematically weaker, but reduces over-deepening in subtropics
- Impact on track is variable
- To be implemented 15 March 2022 due to overall positive impact on model forecasts
 - e.g. better organisation and timing of tropical precipitation



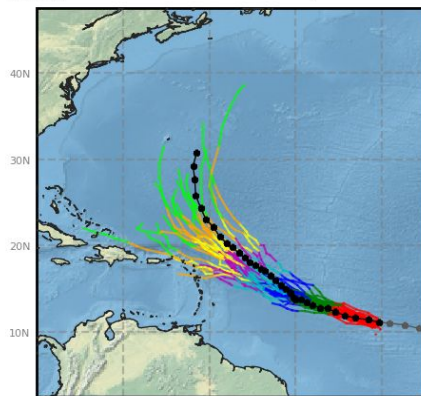
- Loss of intensity spread in MOGREPS-G ensemble, thought to be largely due to systematic weakening in the model
- Later delivery due to later data cut-off and stability enhancements
- Research project under way to investigate perturbing depth and position of TC observations to help improve ensemble spread



MOGREPS-G: Forecast TC tracks for SAM from 00 UTC Fri 24 Sep 2021

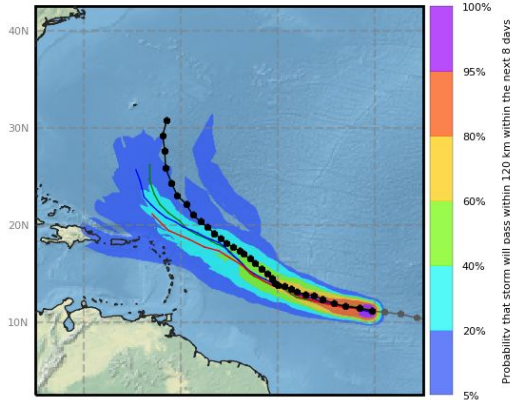


MOGREPS-G-PS: Forecast TC tracks for SAM from 00 UTC Fri 24 Sep 2021

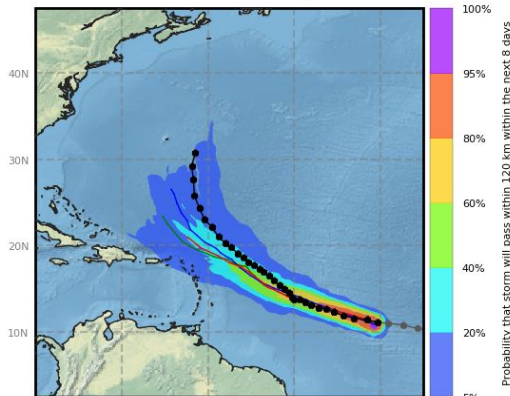


80W 70W 60W 50W 40W
 0-24h 24-48h 48-72h 72-96h
 96-120h 120-144h 144-168h 168-192h
 Observations

MOGREPS-G: Forecast TC track probability for SAM from 00 UTC Fri 24 Sep 2021

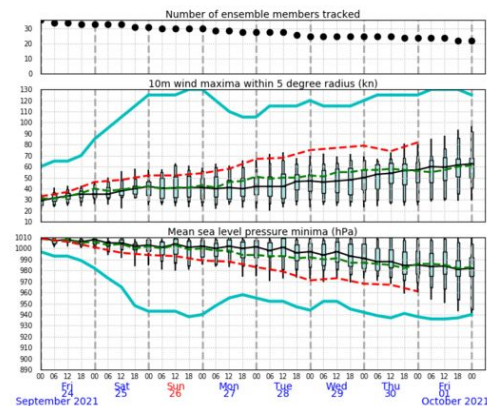


MOGREPS-G-PS: Forecast TC track probability for SAM from 00 UTC Fri 24 Sep 2021

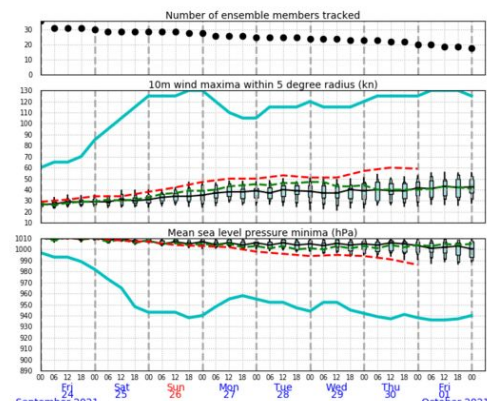


Control Ensemble mean
 Observations Deterministic

MOGREPS-G ensemble: TC-following meteorogram SAM (11.1N 40.3W) from 00 UTC Fri 24 September 2021



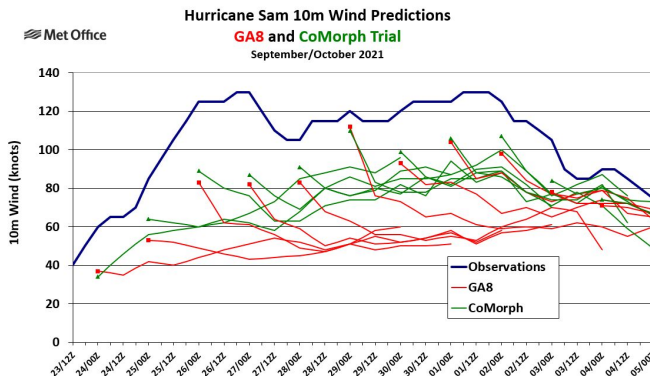
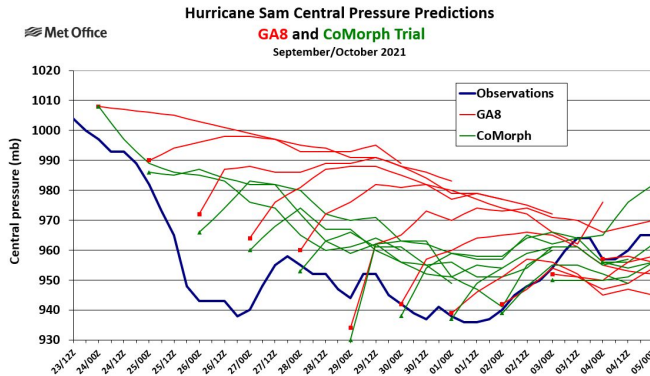
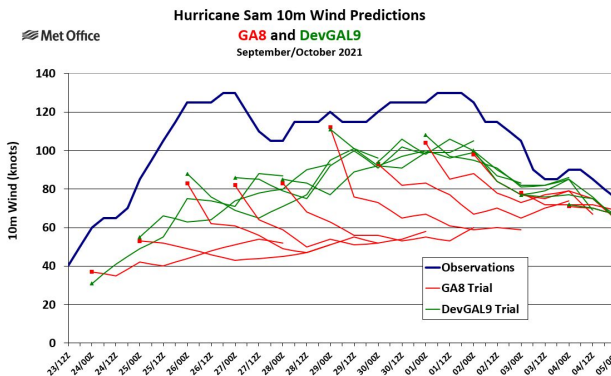
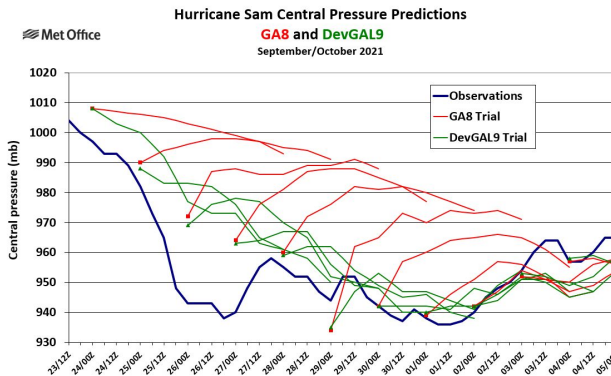
MOGREPS-G-PS ensemble: TC-following meteorogram SAM (11.1N 40.3W) from 00 UTC Fri 24 September 2021



Note: All times on axis are in UTC
 max 90% 75% median 25% 10% min
 Median Control Deterministic Obs

Future Model Developments

- Future changes already under development will reverse systematic weakening and reduce track errors
- Charts for Hurricane Sam compared with atmosphere only version of March 2022 configuration (GA8)
- DevGAL9 (left) – rely on mid-level convection and adjustment to convective detrainment
- CoMorph (right) – a new scale aware convection scheme
- Still much development and wider testing required, so cannot be implemented yet

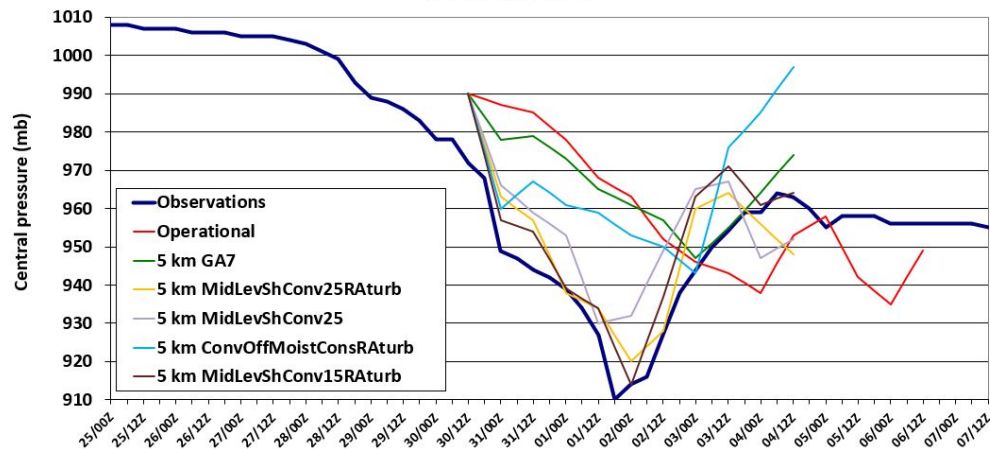


Future Model Developments

- Long term plans to run a 5 km resolution global model
- Experimenting with various science settings
- Hurricane Dorian and Typhoon Goni cases run
- Horizontal resolution not the biggest factor for intensity
- Adjustments to mid-level and shallow convection schemes and turbulence have bigger impact

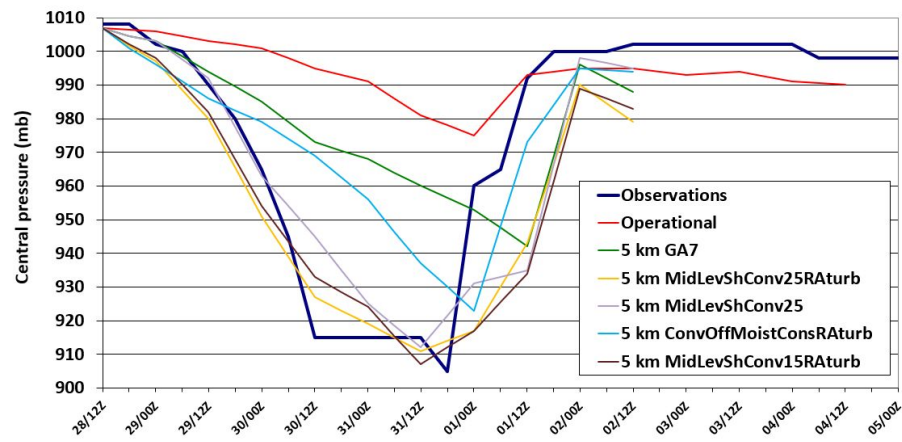
Hurricane Dorian Central Pressure Predictions
Operational and 5 km Global Trials
August-September 2019

 Met Office



Typhoon Goni Central Pressure Predictions
Operational and 5 km Global Trials
October-November 2020

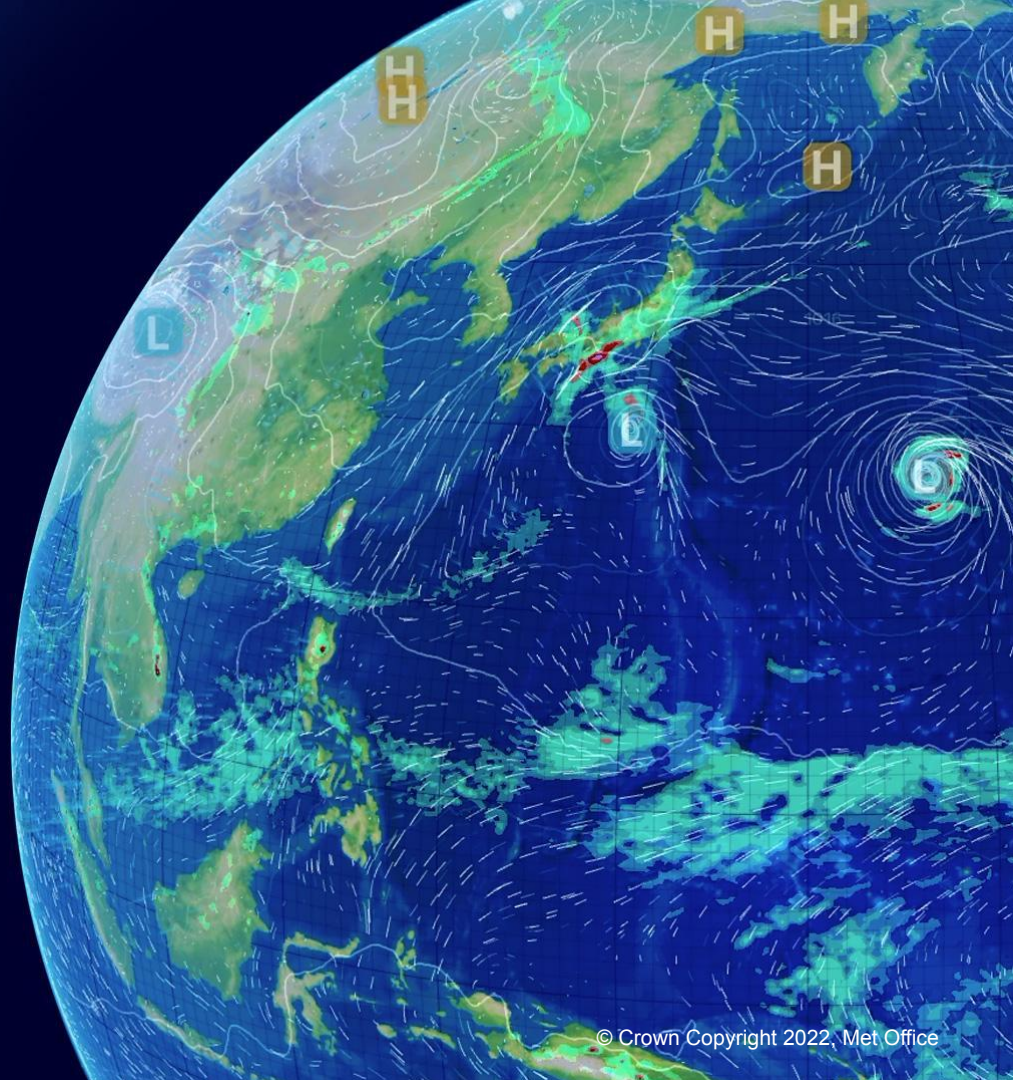
 Met Office



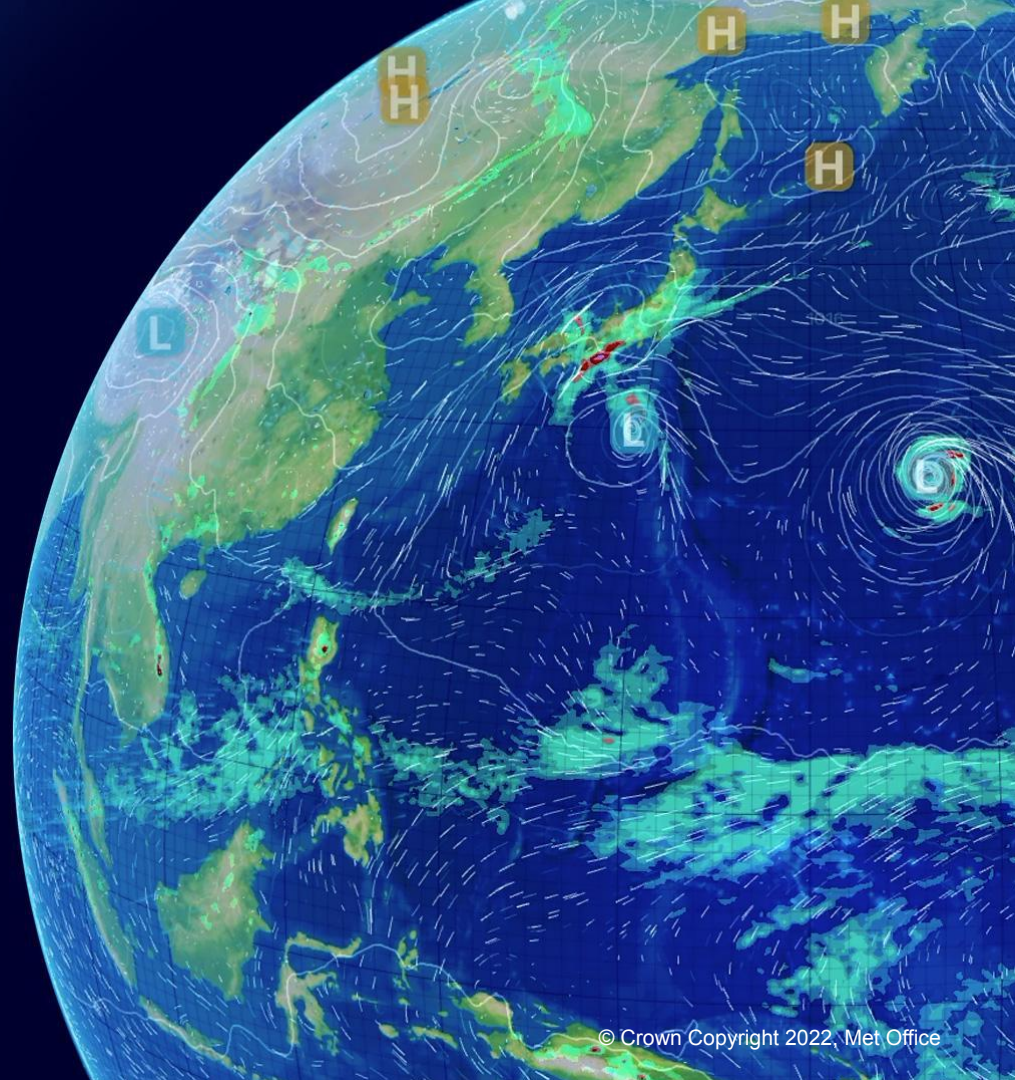
Summary

- Track forecasts good for longest lived TCs (Larry and Sam).
- Ensembles mostly captured tracks even for uncertain cases.
- Intensification not well captured for small TCs and those in deep tropics.
- As found in 2020, cyclogenesis better predicted in main development region than in the Caribbean and Gulf of Mexico.
- Upcoming model change will make TCs weaker – better in subtropics, but not in tropics. Ensemble spread decreased.
- Future plans for global model changes include physics changes, new convection scheme, increased horizontal resolution. All improve TC forecasts in early tests.

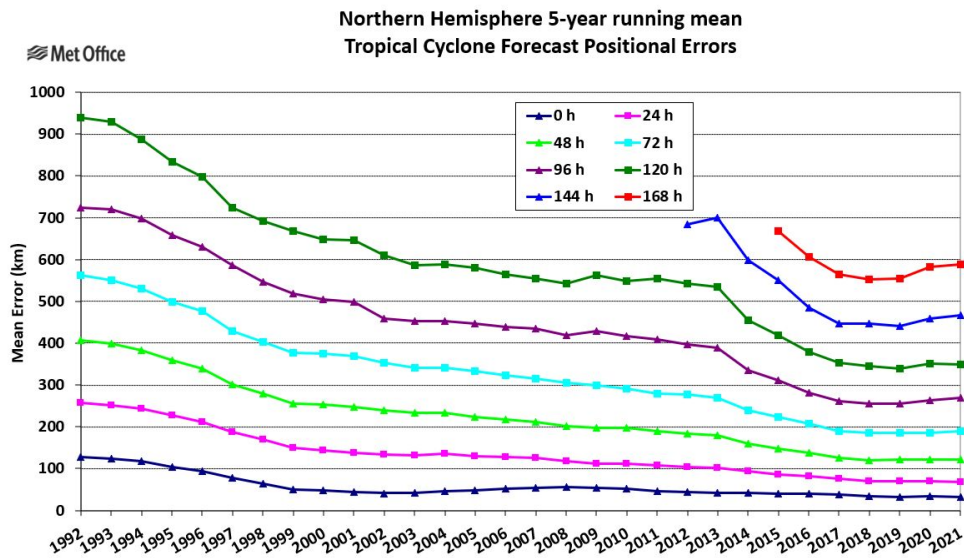
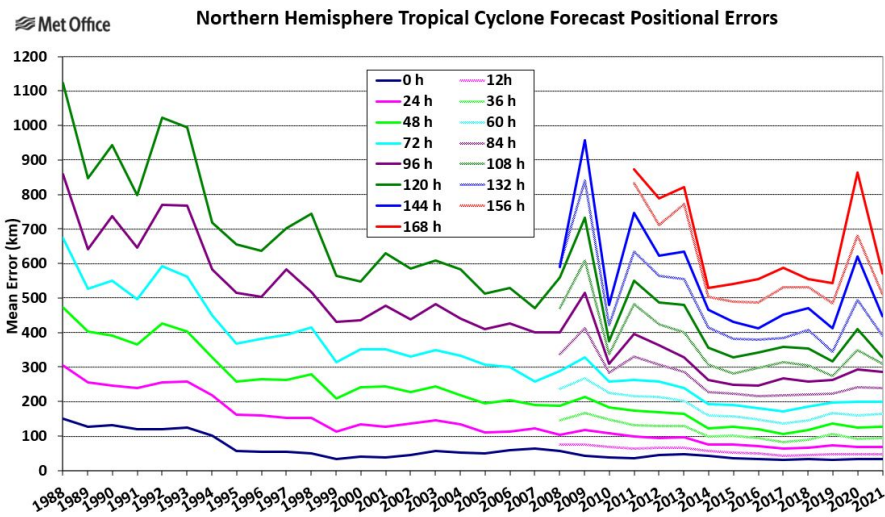
The End



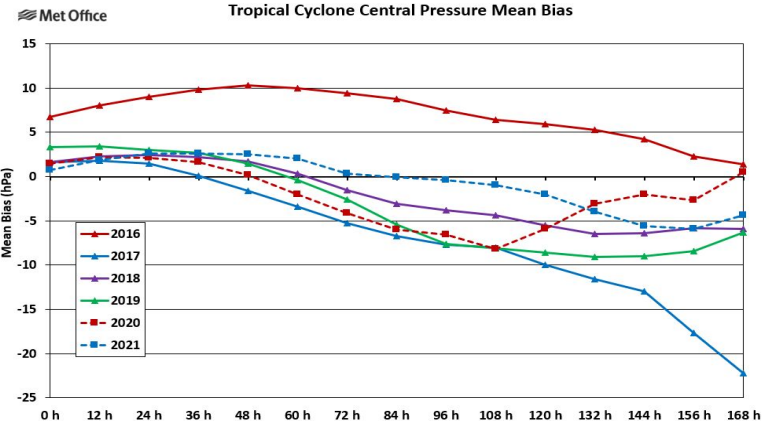
Additional slides
showing more detail



- Northern hemisphere track error on lower than 2020
- Step reduction in 2014 now dropped out of 5-year running mean
- Recent model changes no significant impact on track error



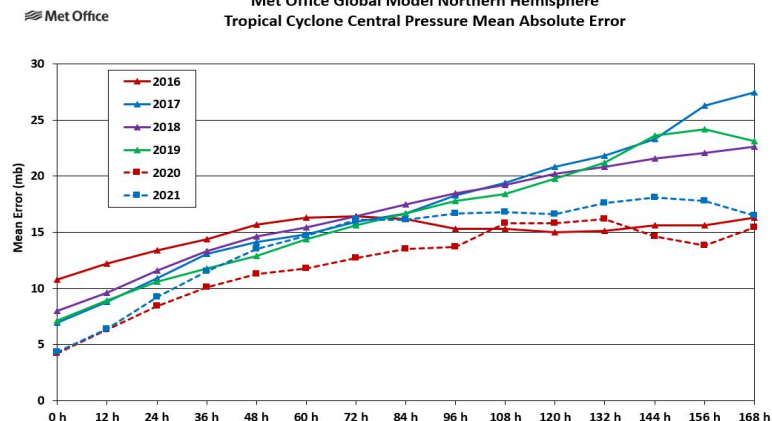
Met Office Global Model Northern Hemisphere
Tropical Cyclone Central Pressure Mean Bias



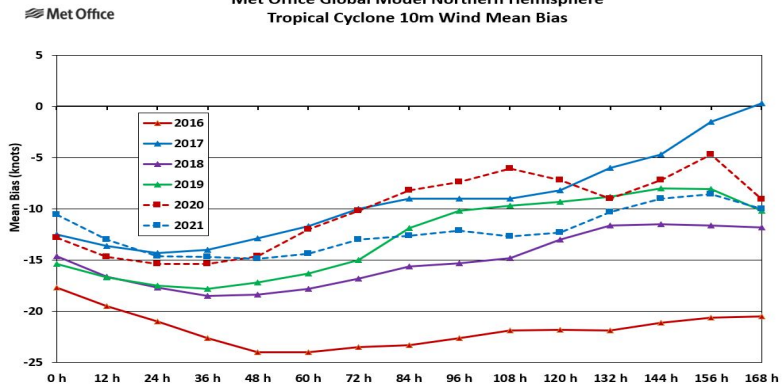
◀ Pressure bias

Pressure absolute error ▶

Met Office Global Model Northern Hemisphere
Tropical Cyclone Central Pressure Mean Absolute Error



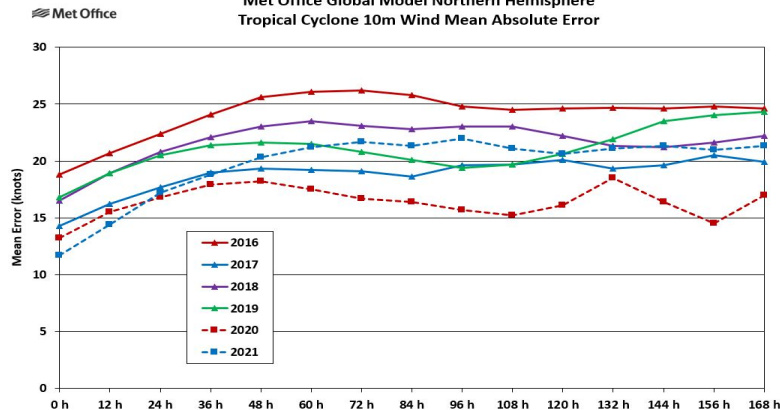
Met Office Global Model Northern Hemisphere
Tropical Cyclone 10m Wind Mean Bias



◀ Wind bias

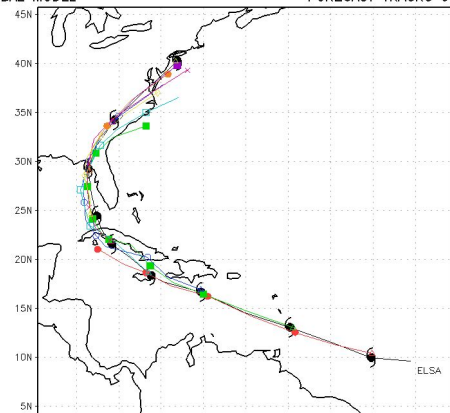
Wind absolute error ▶

Met Office Global Model Northern Hemisphere
Tropical Cyclone 10m Wind Mean Absolute Error



- Met Office models good for track
- MOGREPS-G ensemble captured northwards turn a little earlier than deterministic
- Intensity forecasts mostly poor
- Intensification phases not captured

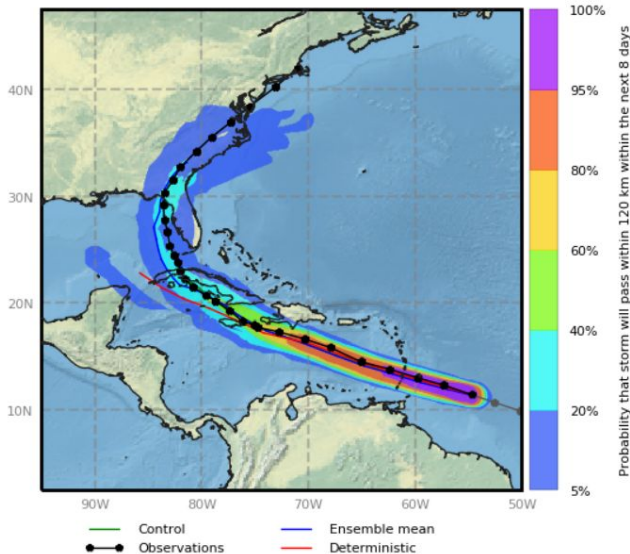
MET OFFICE GLOBAL MODEL FORECAST TRACKS of HURRICAN



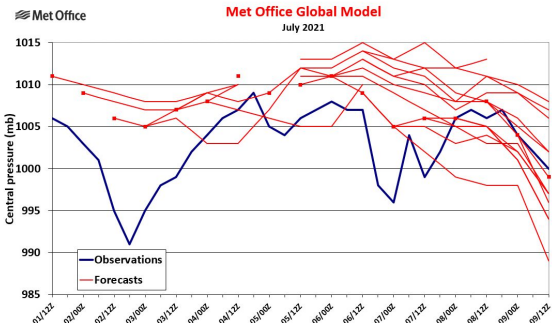
MG 20210701 MG 20210702 MG 20210703 MG 20210704 MG 20210705
 MG 20210706 MG 20210707 MG 20210708 MG 20210709 MG 20210710
 KEY to FORECAST TRACKS
 (Triangles denote analysed positions)

24 HOURLY REAL TIME OBSERVED POSITIONS
 DATE/TIME OF FIRST SYMBOL 12Z 01 JULY 2021

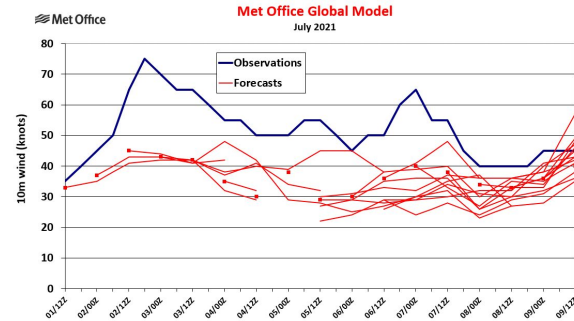
MOGREPS-G: Forecast TC track probability for ELSA from 00 UTC Fri 02 Jul 2021



Hurricane Elsa Central Pressure Predictions

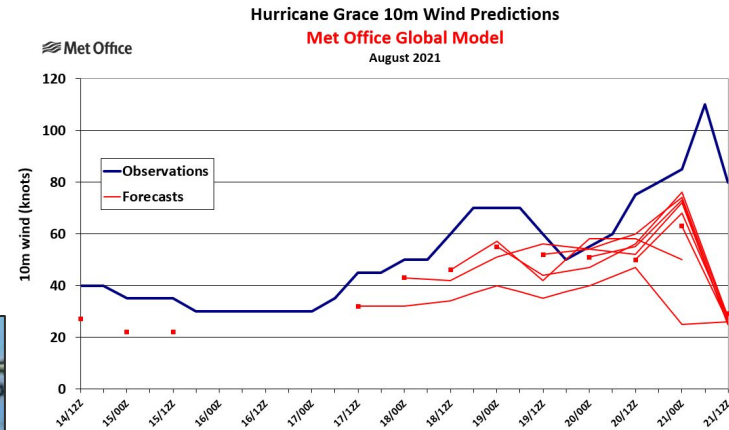
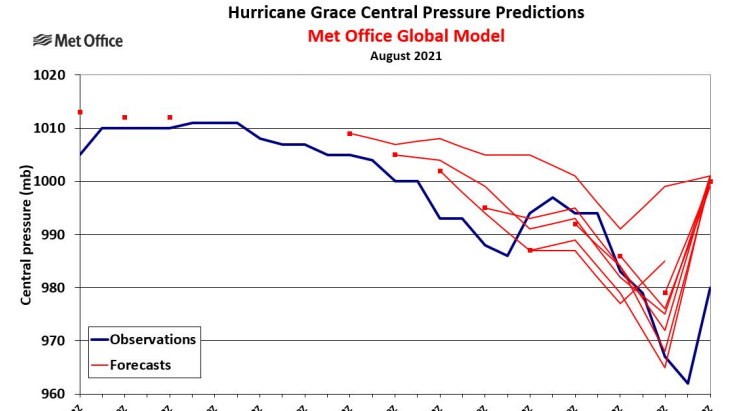
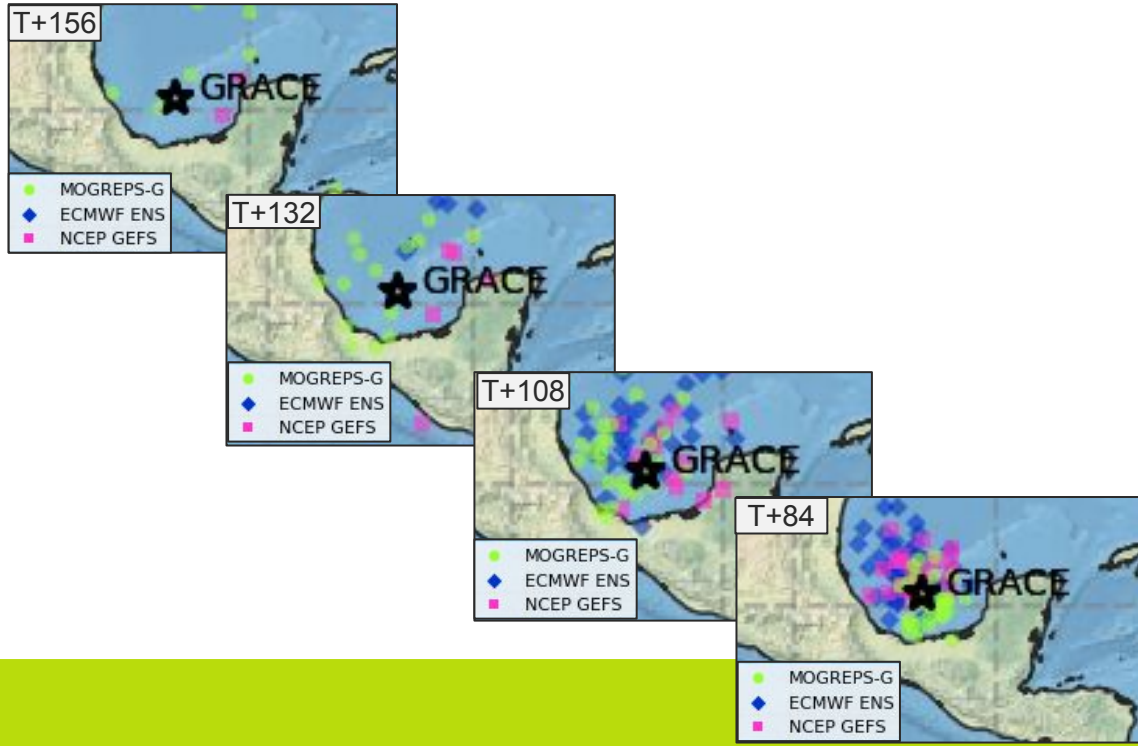


Hurricane Elsa 10m Wind Predictions



Hurricane Grace

- Several MOGREPS-G ensemble members correctly predicted path across Yucatan into Bay of Campeche out to 6+ days, with confidence increasing over subsequent runs
- Intensification in Gulf of Mexico well predicted a couple of days ahead

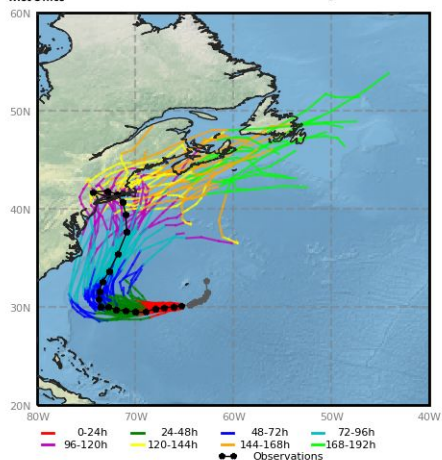


Hurricane Henri

- Uncertainty in track captured by ensemble spread
- Over-intensification by deterministic model

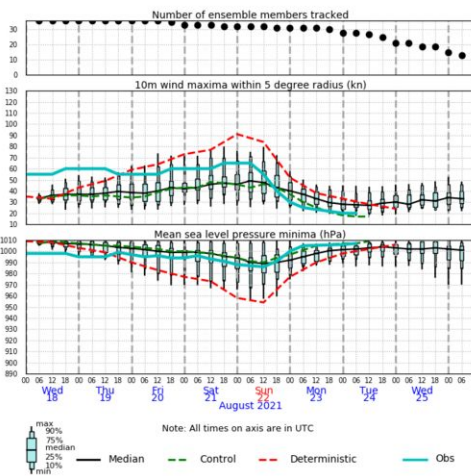


MOGREPS-G: Forecast TC tracks for HENRI from 06 UTC Wed 18 Aug 2021

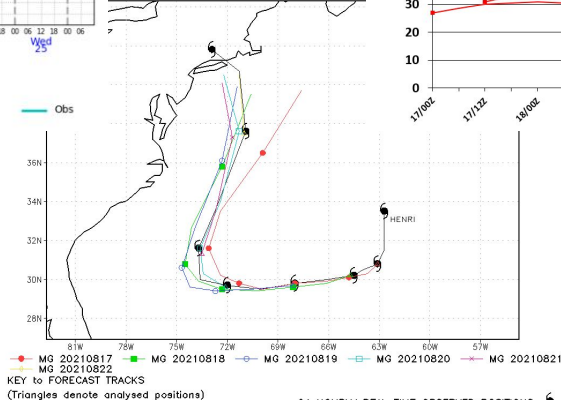


Probability that storm will pass within 120 km within the next 8 days

MOGREPS-G ensemble: TC-following meteorogram HENRI (30.1N 65.3W) from 06 UTC Wed 18 August 2021

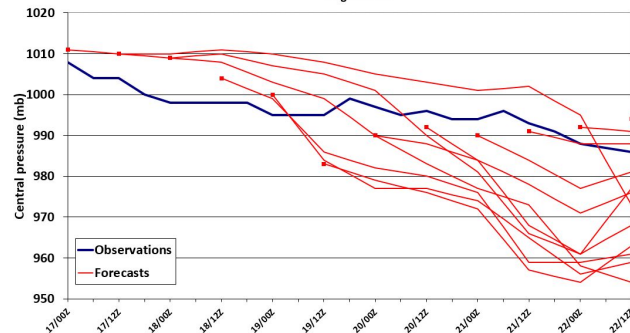


MODEL FORECAST



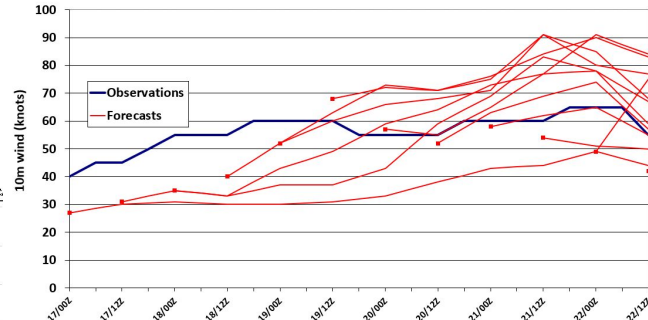
Met Office

Hurricane Henri Central Pressure Predictions
Met Office Global Model
August 2021



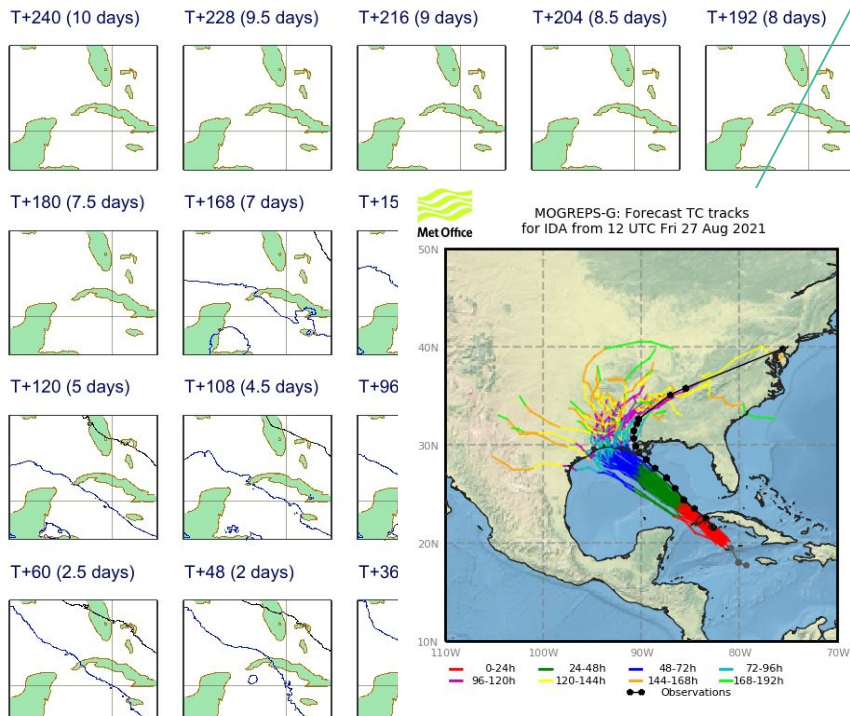
Met Office

Hurricane Henri 10m Wind Predictions
Met Office Global Model
August 2021

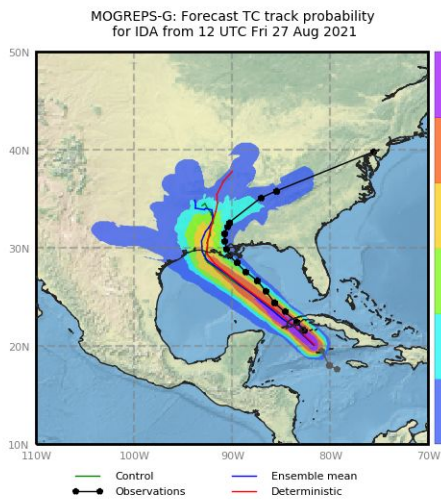
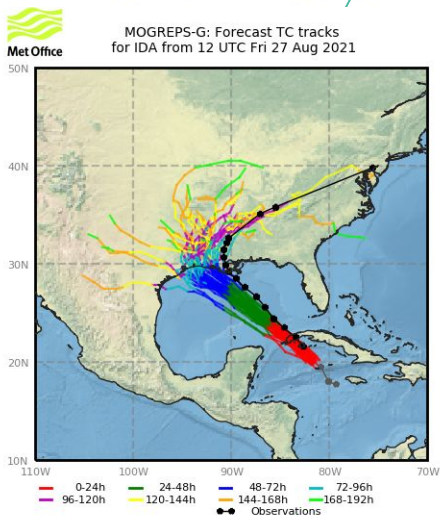


Hurricane Ida

- Cyclogenesis poorly forecast in deterministic (> 48 h) and ensembles (> 72 h)
- Left bias in model forecasts, but spread covered track
- Forecast intensity too weak



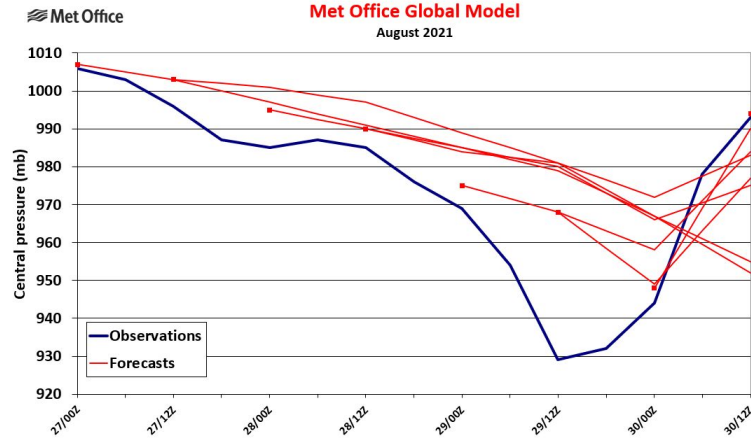
Met Office Global Model
MSLP forecasts for
Hurricane Ida
valid at
00Z 28-08-2021
4mb contour interval
blue <= 1012mb
green <= 1004mb
red <= 996mb



Hurricane Ida Central Pressure Predictions

Met Office Global Model

August 2021



MOGREPS-G ensemble: TC-following meteorogram
IDA (20.4N 81.6W) from 12 UTC Fri 27 August 2021

